officer provided he is assure of the cleanliness of all our facilities and all the techniques that we have used. He comes often to inspect our facilities and our growing on areas.

VEGETATIVE PROPAGATION TECHNIQUES — CURRENT IDEAS IN BRITAIN

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The last decade has seen many innovations in the production of hardy nursery stock within the British Isles, many of which have been directed to a number of aspects relating to plant propagation. The objective of this paper is to itemize some of the technical developments that have taken place within the last three years, in addition to those currently being used.

Before looking at some individual topics, it will first be helpful to summarize some of the current trends in British plant propagation:

(1) Nurseries specializing in individual crops, such as *Clematis*, are developing specialized growing systems — for example, liner production. This has been particularly noticeable with the formation of newer businesses and also in the rationalization that has occurred within some established companies.

(2) The production of crops if Britain that are traditionally imported from abroad, for example, rose rootstock and tree seedling rootstocks.

(3) Techniques to reduce fuel costs in propagation, which, in turn, have led in a number of instances to a simplification of plant propagation facilities.

(4) The use of polyethylene film for rooting cuttings in the winter as an alternative to mist propagation. Nurserymen have experienced problems with mist over the winter, in particular, due to excess water application leading to leaf drop on cuttings, increased fungal disease, and excess water in the rooting media.

(5) The interest by nurserymen in the growing of new plant introductions. This has been particularly evident in the plant lists of some of the more recent formulated nurseries.

Blooms Nurseries of Bressingham, Norfolk, have introduced a number of new junipers from the United States, as well as producing phormiums from New Zealand. Also, Alan Thompson Nurseries at Windlesham, Surrey, are now offering a good range of the Darthuizer selection of shrubs from Holland. Hadlow College, in Kent, England, is collating and propagating up the different selections of *Kalmia latifolia* made by Richard Jaynes in Connecticut.

(6) The formation of a clonal selection scheme at Long Ashton Research Station, Bristol, for the major commercial lines grown by nurserymen.

(7) The emphasis on the correct siting and culture of stock plants.

(8) Tissue culture (micropropagation) has instigated a great deal of interest in the nursery trade, but it is not as well developed for ornamental woody plants as in North America. Its role has mainly been in research and for the growers of glasshouse crops.

(9) The importance placed on skills training in nurseries, which is assisted by a government-backed organization called the Agricultural Training Board. Also, educational establishments have provided more courses of a more specialized nature, catering to the different sectors of the horticultural industry, including the nursery stock grower.

(10) Mechanization and handling to streamline production systems, for example, greater emphasis to direct rooting and the importance of work organization. A recent project undertaken by the Ministry of Agriculture's Advisory Service (Extension Service) has been developed under the guidance of Brian Morgan in the preparation of softwood cuttings.

STOCK PLANTS

Siting and Planning. A number of production systems are dependent on the growing crop to provide the initial cutting material. The value of having a designated area in the nursery for stock plants is now fully appreciated by many nurserymen. The advantages of permanent stock plants have been well documented and include such practices as being able to "manipulate" stock plants by different pruning techniques to induce juvenility as an aid to rooting and also to provide a maximum number of well-graded cuttings from the minimum area. Careful selection and planning is necessary, otherwise time and space is wasted by overplanting with material that is easy to root, as they may be very prolific in producing large numbers of cuttings. At the other extreme, there may be the planting up of a low number of stock plants that do not fulfill

the requirements of the propagation program. The site of the stock plant area can be categorized as follows:

(1) Outdoor areas, ideally grown in the hedge system, where consideration has been given to shelter, soil improvements, and effective weed control prior to planting.

(2) Siting the stock plants under protection, for example, a structure clad by polyethylene or with a woven plastic material (shade cloth) providing between 40 and 60% shade. This system particularly interested me at Hadlow College in Kent where it was used for a wide range of woody plant material. We used it mainly for the high value deciduous shrubs, such as *Magnolia, Acer, Rhododendron, (azalea), Hamamelis, Fothergilla*, and *Corylopsis* for a number of reasons. It was found that cladding with woven plastic material was more advantageous than polyethylene. The great advantage of this system is that cutting material is available earlier in the season and one is able to collect it in the ideal condition over a longer period of time. The percentage rooting take is then improved and, in turn, one is able to improve the overwintering performance of the subsequent young plants by reducing losses.

Clonal Selections. In 1975 an important clonal selection scheme was initiated at Long Ashton Research Station, Bristol. This has received the full backing of the nursery trades associations in Britain (National Farmers Union/Horticultural Trades Association). Through grower meetings and the national press, nurserymen have been invited to submit material to the scheme for a list of plants being formulated by a committee. This committee is made up of nurserymen, research and extension workers, educationalists, botanic garden personnel, and plantsmen. The material submitted is examined by the committee during the growing year for such factors as trueness-to-name, habit, form, and plant health, together with ease of propagation. Plants selected from those submitted are bulked up and then released under a reference code, for example, LA 79 (Long Ashton 1979). Four plants that have now been released are *Cornus alba* 'Spaethii', *Daphne* 'Somerset', *Forsythia intermedia* 'Lynwood', and *Potentilla* 'Tangerine'. Considerable variation has been found in a number of plants assessed, for example, *Potentilla* 'Tangerine', *Cornus alba* 'Spaethii', *Virburnum farreri*, and *Philadelphus* 'Virginal'. However, on the other hand, little variation has been found in some plants and it has not warranted individual selection and subsquent bulking up, for example, *Hypericum* 'Hidecote'. For the future, the scheme plans to clonally assess some 100 different commercial lines over the next five years, including climbers, trees, shrubs, and conifers.

The Plant Introduction Scheme of the University of British Columbia Botanical Garden has negotiated to participate in the scheme and we shall be sending material this fall for their 1981-82 requirements. These include *Vitis coignetiae* and *Prunus laurocerasus* 'Otto Luyken'. In turn, it is planned that we shall receive the clonal selections from Britain and establish them in the Botanical Garden nursery. We then hope to include these selections in one of the scheme's objectives by collating and establishing improved and new clones of plants for distribution to the nursery trades within British Columbia.

An example of clonal assessment is seen by the work of David Whalley at the Glasshouse Crops Research Institute on a Leyland cypress, × *Cupressocyparis leylandii*. His studies have included assessments on rooting potential, growth rates, and field establishment of this important hedging plant. He showed that these are two clones (Clone 21 and Clone 121) that show definite improvement in rooting and growth rate compared with presently used clones (Clone 2 and Clone 11). Growth rates were evaluated and Clone 10 ('Naylors Blue') proved to be the slowest while Clone 122 was the fastest.

Pruning. Some major research directed towards the correct pruning of stock plants has been carried out at Efford Experimental Station by Margaret Scott. This work has been in progress for only a short period of time, but the results have shown a number of interesting observations; for example, spring and June pruning of *Virburnum* × *burkwoodii* are best for the production of high numbers of good quality cuttings for rooting in September/October. Records are being collected to provide information on the number of cuttings produced from a given number of stock plants as the years progress. We also carried out a number of pruning treatments in the stock plant area at Hadlow College and had some interesting results, particularly with *Garrya elliptica*, *Elaeagnus pungens* 'Maculata' and the dawn redwood, *Metasquoia glyptostroboides*.

PLANT PHYSIOLOGY

The Plant Propagation Department at East Malling Research Station, Kent, which has recently moved into new premises, is headed by Dr. Brian Howard. Examples of two lines of work that he and his colleagues are undertaking to increase knowledge on the internal mechanism of woody plants are:

(1) The preconditioning of shoots while still on the stock plants where etiolation has been induced, using black polyethylene structures, is being studied. These tents are placed over the hedges of stock plants prior to bud burst. This has been further developed by Margaret Scott for a wider range of

woody plants at Efford Experimental Station. This investigation will be particularly valuable to give one a further insight into the improvement of rooting of normally difficult-to-propagate plants.

(2) The influence of co-factors on the seasonal rooting of cuttings where current evidence suggests that the increase in bud activity in the spring does not directly influence the rooting of dormant woody cuttings.

Another example of research is plant physiology has been carried out by Dr. Keith Loach at the Glasshouse Crops Research Institute, Sussex. His work has been examining the problem in mist propagation that small water droplets have great difficulty in being directed to the underneath of the leaf lamina where the majority of stomata are sited. Thus, modifications in the environmental conditions to improve the situation would no doubt be beneficial to the plant propagator. He has indicated the value of providing a situation where cooler air is passed over and through the cuttings in a horizontal movement to reduce leaf temperatures. He has since recommended that this requires further examination as field research. He is also interested in environmental research to increase our knowledge of the interaction between carbohydrates, light, and the actual rooting process.

PLANT PROPAGATION FACILITIES — REDUCING FUEL COSTS

Some recommendations for reducing fuel costs have come from the work of Margaret Scott at Efford Experimental Horticultural Station in Hampshire. It can best be itemized under the following headings:

Polyethylene Film. The use of polyethylene film as an alternative to mist for winter rooting of cuttings was mentioned earlier in this paper. The reasons for this include problems related to excess water: a) producing saturation of the rooting compost, b) accentuating leaf drop, and c) increasing the incidence of fungal disease.

Expanded Polystyrene Sheets. Between 20 and 50% savings in fuel costs have been achieved by insulating the base, sides and ends of the propagation bed with expanded polystyrene sheets. The normal procedure is to wrap 2.5 cm thick sheets of polystyrene within polyethylene film. One trial in an unheated polyethylene structure to insulate a ground level bed with a base temperature of 18°C in March and April resulted in 30% saving in electricity consumption.

Duration of Basal Heat. Trials have been carried out to

provide basal heat at night time only, when off-peak electricity tariffs are available. Basal heat during the day is provided by natural solar radiation only. Subjects such as *Hebe* and *Choisya*, which are quick rooting, have shown little difference in the time taken to root; however, slower-rooting plants, such as *Camellia*, have required a further four weeks for rooting.

Electronic Temperature Controller. Generally rod thermostats are inefficient for two reasons. Firstly, they only record the basal temperature at one specific point within the propagation bed, and secondly, they can be quite varied in their response to a change in temperature. A system now being installed by some British nurserymen is an electronic temperature controller manufactured by Nobel Engineering, Worthing, Sussex. This is a system with 4 to 6 thermo-coupler sensors connected to one main controller. The required temperature is set on the main dial and the thermo-coupler sensors then provide an average reading over the bed at the depth at which the cutting is stuck. There is an easy readout system by which the average temperature of the bed can easily be seen. This equipment is very fast in recording a temperature drop, and also in bringing it up to the desired level. Inaccurate temperature control wastes energy and produces wide fluctuations in temperatures. Charles Tubesing, the Nursery Manager of the University of British Columbia Botanical Garden nursery, has two of these now installed and has found them very satisfactory so far.

Choice of Container for Rooting. The studies at Efford also included the assessment of the effectiveness of heat transfer to the rooting media using different types of containers. The results showed the importance of the container design and material in providing good contact between the rooting media container and the sand base beneath. For example, it was found that the temperature of an expanded polystyrene seed tray could only be raised with difficulty above 17.5°C, whereas 21°C was easily obtained using either a polypropylene seed tray or an expanded polystyrene cell unit tray.

Other Aspects. Work at Efford has evaluated the benefits of providing a thermal screen using a range of different materials. In fact, a total energy saving of 60% was achieved when beds were insulated with 2.5 cm expanded polystyrene sheets with the addition of an overhead thermal screen of aluminized polyester material.

The nurseryman has adapted these results for his own propagation requirements and facilities. For example, a recently established nursery at Broadhouse Farm, Droitwich, Worcestershire, has put the ideas into practice in their liner

production nursery. One of the leading nurseries in Britain, Notcutt's Nurseries, Woodbridge in Suffolk, has also adapted these results for their very ambitious new propagation unit, where basal heat from hot water is provided by panels that are joined end to end to cover the floor. These panels are covered by 5.0 cm thick polystyrene sheets wrapped in polyethylene, and capillary matting is then placed over the sheets. The cutting trays are laid on top of the matting itself. A mobile gantry system is installed over each of the propagation beds to make handling more efficient.

FIELD PROPAGATION

Layering. This reliable technique has been carefully reconsidered at a few nurseries, despite the large area of land it utilizes. An example is at Exbury Gardens Ltd. in Hampshire where the manager, Douglas Harris, has initiated new layer beds to produce a range of difficult-to-propagate rhododendrons, which are normally grafted or slow-to-produce, saleable plants from cuttings.

Due to the problem of specific replant disease *Thielaviopsis fasicola* and root gall *Agrobacterium* spp, combined with the introduction of the cherry rootstock, *Prunus* 'Colt', the traditional trench layering method for producing the 'F 12/1' selection of *Prunus avium* is quickly declining.

Rootstocks. The virtues of *Prunus* 'Colt', with its ability of being able to develop preformed root initials while still on the mother plant, have been well documented. Shade tree producers have shown interest in the more recent introduction by East Malling Research Station of *Prunus* 'Cob'. This is another selection from the *Prunus avium* and *Prunus pseudocerasus* hybrids developed by the Plant Breeding Department, which has greater vigour than *Prunus* 'Colt' and produces trees with good girth and straight stems.

Dr. Howard's department at East Malling is selecting clones of *Tilia* × *vulgaris* (Syn.: T. × *europaea*) and *Tilia cordata* for clonal propagation, based on rooting ability properties during the winter period. In addition, their compatibility characteristics are also being studied.

CHIP BUDDING

This old technique, used for many years in propagating grapes, and recently developed for fruit trees at East Malling Research Station by Dr. Howard, is now an established practice on commercial tree nurseries. Its advantages over shield or 'T' budding have been well documented in his publications. These advantages include the ability to bud over a longer

period of time to improve bud take, and so obtain a more even stand of trees with increased number of lateral shoots. More recently the technique has enabled tree growers to increase the number of subjects that may be field-budded, for example, *Gleditsia triacanthos* var. *Inermis* 'Sunburst', and *Betula alba* cultivars.

During a recent visit made by Dr. Howard to Vancouver, we discussed a new tie that East Malling and a commercial firm in Britain (Rapidex, Knutsford, Cheshire), have developed for chip budding. Initial trials suggest that the tie has sufficient strength to tie in firmly, and it also has the property of degrading within a period of 4 to 6 weeks from the time of budding. Polyethylene tape, the usual tie material, has to be removed. Thus, the major advantage of this new tie is that there is no need to remove it, thus saving on labour time.

The University of British Columbia Botanical Garden has commenced some joint training sessions with the BCNTA (British Columbia Nursery Trades Association), and one of the subjects dealt with has been chip budding. These courses have been held at nurseries in the Fraser Valley and some of the tree growers have been given these ties for assessment. It will be interesting to report back at a later date with the results.

CONCLUSIONS

The British Nursery Trades, like many other industries, have been suffering in the recession with high interest rates, high unemployment, and cutbacks in both private and public spending. The British nurseryman is resourceful and is now in a stronger position to adapt his growing techniques and market where necessary. From recent personal contacts, I am sure that the majority will come through this difficult period successfully.